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FETUSES OF THE GUIANA HOWLING MONKEY

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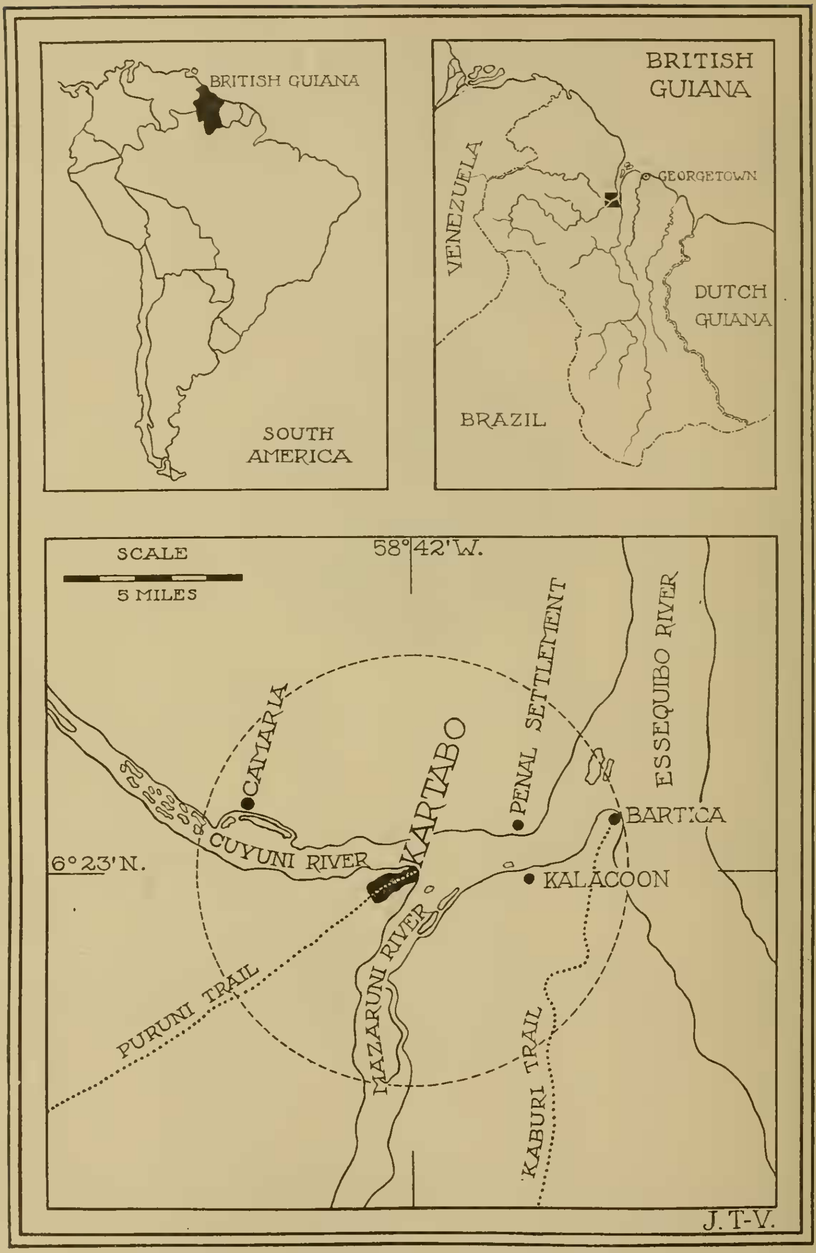

LOCATION OF THE TROPICAL RESEARCH STATION OF THE NEW YORK ZOOLOGICAL SOCIETY

The circle represents a radius of six miles.

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Our knowledge of the development of the monkey is still very limited. This is especially true in regard to platyrrhines, most of the scanty literature dealing with Old World monkeys. Just as in the case of human development, more work has been done on the early than on the later stages of fetal development. It is only through a complete knowledge of the entire intrauterine development of the different monkey genera, however, that we may hope to understand fully their position in the system of primates, their relation to each other, and their various specializations and differences, problems of equal importance to the zoologist, as well as to the comparative anatomist and scholar of evolution. Furthermore, such knowledge will prove of great interest to the embryologist and physical anthropologist, who may derive therefrom a clearer insight into the laws governing growth and the conditions of development of the various parts of the body.

The following notes form a small contribution in this direction; they comprise a description of two older fetuses of a howling monkey from South America. These specimens were given by Mr. William Beebe, Director of the Tropical Research Station of the New York Zoological Society, to the Carnegie Laboratory of Embryology. In addition to the fetuses, use has been made of observations on the skeleton of an adult male Alouatta, lent by Mr. Beebe, and another skeleton of an adult and two preserved bodies of juvenile male Alouattas from the anatomical collection of the University of Zürich. The author wishes to take this opportunity to express his sincerest thanks to Mr. Beebe for this valuable material, and to Prof. W. Felix for his kind permission to study the specimens of the Anatomy in Zürich.

The sub-species of monkey to which the fetuses and one of the skeletons (No. 4) belong is *Alouatta seniculus macconnelli* Elliot, the Guiana howling monkey (Beebe, '19). The other skeleton

(No. 3) and the two preserved bodies (Nos. 1 and 2) are of the species *Alouatta seniculus* L.[1] The rarity of the fetuses is increased by the fact that they are twins, twinning in monkeys being to all appearances not any more frequent than in man.[2] From an examination of the fetal membranes it is evident that the fetuses are monozygotic or single-ovum twins. Both are males and one of them is slightly larger than the other, their respective sitting-heights (crown-rump lengths) being 111 mm. (twin A) and 105 mm. (twin B). To what actual age this size corresponds it is impossible to tell. The duration of pregnancy in Alouatta is probably not more than five months,[3] and the fetuses in question had reached certainly the second half of their intrauterine development. Through a careful comparison with the human it is found that the development of these monkey fetuses corresponds most closely with that of a human fetus of twenty weeks, but no doubt they are actually younger. In respect to the state of development of the lanugo, the ears, genitals, hands and feet, and of ossification, the Alouatta fetuses are analogous to human fetuses of the twentieth week, but the latter are considerably larger, their sitting-height being on an average 154 to 164 mm.

[1] The sub-species of these cannot be determined.

[2] Selenka ('92) mentions one case of twins in a *Cercocebus cynomolgus* and Fitzsimons ('19) records two instances of twins in *Papio porcarius* and one in *Cercopithecus pygerythrus*.

[3] Bluntschli ('13) gives the duration of pregnancy for Cebus and Chrysothrix as 4½ to 5 months.

TABLE 1.

ABSOLUTE MEASUREMENTS OF THE ALOUATTA FETUSES

No.	Measurement (in millimeters):	twin A.	twin B.
1.	Sitting height: Top of head to lowest point on buttocks	111	105
2.	Thoraco-abdominal height: Symphysion (upper border of symphysis pubis) to suprasternal notch..........	52.5	47
3.	Symphysion to nipple (the latter projected on midsagittal plane)	47	40
4.	Symphysion to omphalion (center of attachment of umbilical cord)	18	14.8
5.	Biacromial diameter: Distance between the acromial processes	30	28.5
6.	Bimammillary diameter: Distance between nipples.....	21	18.8
7.	Bitrochanteric diameter: Distance between the great trochanters	21.7	21
8.	Transverse diameter of chest (at nipple height).......	27.7	26.4

9. Sagittal diameter of chest (at nipple height)	24	23.8
10. Circumference of chest (at nipple height)	87	84
11. Length of upper arm: Top of caput humeri to humero-radial joint (radiale)	32	31
12. Length of forearm: Radiale to tip of styloid process (stylion)	27.2	26.9
13. Length of hand: Middle of line combining styloid processes of radius and ulna to tip of middle finger	25.7	23.3
14. Length of thumb: Stylion to tip of thumb	15.2	14.8
15. Breadth of hand (across metacarpo-phalangeal joints (II to V)	12	11.3
16. Length of thigh: Top of great trochanter to lateral point of knee joint	30.6	29.6
17. Length of leg: Medial point of knee joint (tibiale) to tip of internal malleolus	25.5	25
18. Tibiale to sole of foot	31.3	29.9
19. Length of foot: Heel to tip of longest toe	33	32.1
20. Breadth of foot (across metatarso-phalangeal joints II to V + breadth of this joint on great toe)	13	12.8
21. Greatest length of head: Glabella to most distant point on head	39.4	38.1
22. Greatest breadth of head: (over temporal or parietal bones)	32	31
23. Auricular height of head: Tragion (upper border of tragus) projected on midsagittal plane to vertex (perpendicular to ear-eye horizon)	21.5	21.2
24. Nasion-inion diameter: Point over middle of naso-frontal suture (nasion) to occipital protuberance (inion)	39.2	38.1
25. Biauricular breadth: Width between the tragion points	31	29.6
26. Horizontal circumference of head (greatest circumference passing through glabella)	115	110
27. Sagittal arc: Nasion to inion	61	56.9
28. Transverse arc: Tragion to tragion (perpendicular to ear-eye horizon)	67.5	64.3
29. Total head height: Lowest point of chin (gnathion) to vertex (perpendicular to ear-eye horizon)	37	36.2
30. Total face height: Nasion to gnathion	17.2	17
31. Upper face height: Nasion to middle of mouth	12.3	12.4
32. Bizygomatic breadth: Greatest breadth between zygomatic arches	31	29.8
33. Nasal height: Nasion to subnasal point (where nasal septum and upper lip meet)	9.3	9.7
34. Nasal breadth: Greatest breadth between nasal wings	9.4	9.2
35. Breadth of nasal septum: Smallest distance between nostrils	3.8	3.6
36. Interocular breadth: Distance between medial angles of eyes	8	7.9
37. Breadth of mouth	15	13.5
38. Length of ear: Highest point on helix to lowest point on lobule	12.7	12.4
39. Breadth of ear: Greatest breadth between anterior and posterior border of helix	9	8.6

TABLE 2. INDICES OF FETAL, JUVENILE, AND ADULT ALOUATTA AND OF HUMAN FETUSES. THE NUMBERS IN PARENTHESIS IN THE FORMULAE REFER TO THE NUMBER OF THE MEASUREMENT IN TABLE 1.

No.	INDEX	Formula:	*Alouatta seniculus macconnelli.* Fetuses		*Alouatta seniculus*			*Alouatta senicul. maccon.*	Average of nine negro Fetuses 20th Week
					Bodies. Juveniles.		Skeletons. Adults.		
			Twin A	Twin B	1.	2.	3.	4.	
I.	Relative biacromial diameter	$\frac{(5)}{(2)} \times 100$	57.1	60.6	43.3	41.3	....	....	70.5
II.	Relative bitrochanteric diameter	$\frac{(7)}{(2)} \times 100$	41.7	44.7	45.0	45.2	....	....	54.3
III.	Relative circumference of chest	$\frac{(10)}{(2)} \times 100$	165.6	178.6	121.6	145.2	....	....	207.2
IV.	Thoracic index	$\frac{(8)}{(9)} \times 100$	115.4	110.9	102.3	98.0	....	....	119.1
V.	Relative bimammillary diameter	$\frac{(6)}{(8)} \times 100$	75.8	71.2	90.5	89.8	....	....	62.5
VI.	Relative position of nipple	$\frac{(3)}{(2)} \times 100$	89.6	85.1	100.0	101.6	....	....	77.1
VII.	Relative position of umbilicus	$\frac{(4)}{(2)} \times 100$	34.3	31.5	....	....	....	....	19.3
VIII.	Relative length of upper extremity	$\frac{(11)+(12)+(13)}{(2)} \times 100$	161.6	172.6	167.4	166.2	....	....	142.4
IX.	Humero-radial index	$\frac{(12)}{(11)} \times 100$	85.0	86.8	87.5	86.3	88.0	91.4	78.2
X.	Forearm-hand index	$\frac{(13)}{(12)} \times 100$	94.5	86.6	88.0	87.7	....	79.9	78.7
XI.	Relative length of thumb	$\frac{(14)}{(13)} \times 100$	59.2	63.6	62.1	59.5	....	57.5	69.5
XII.	Hand index	$\frac{(15)}{(13)} \times 100$	46.7	48.7	35.0	38.0	....	....	51.3
XIII.	Relative length of lower extremity	$\frac{(16)+(18)}{(2)} \times 100$	117.8	126.5	134.1	130.9	...	....	130.0
XIV.	Femoro-tibal index	$\frac{(17)}{(16)} \times 100$	83.4	84.5	87.3	87.6	88.8	92.8	82.1
XV.	Leg-Foot index	$\frac{(19)}{(17)} \times 100$	129.3	128.4	115.8	121.0	....	100.0	83.2

XVI.	Foot index	$\frac{(20)}{(19)} \times 100$	39.4	39.9	30.0	32.6	....	...	41.6
XVII.	Intermembral index	$\frac{(11)+(12)+(13)}{(16)+(18)} \times 100$	137.0	136.4	124.8	126.8	....	...	109.7
XVIII.	Femoro-humeral index	$\frac{(11)}{(16)} \times 100$	104.5	104.7	96.2	98.8	99.4	97.8	91.4
XIX.	Tibio-radial index	$\frac{(12)}{(17)} \times 100$	106.6	107.5	96.4	97.2	98.5	96.4	87.2
XX.	Foot-hand index	$\frac{(13)}{(19)} \times 100$	77.9	72.6	73.2	70.4	....	77.0	82.5
XXI.	Relative size of head	$\frac{(26)+(27)+(24)+(28)+(25)}{3 \times (1)} \times 100$	94.2	94.9	69.6	72.7	....	....	105.3
XXII.	Head-trunk index	$\frac{(21)+(22)+(23)}{3 \times (2)} \times 100$	59.0	64.0	39.0	40.7	....	....	71.2
XXIII.	Cephalic index	$\frac{(22)}{(21)} \times 100$	81.2	81.4	81.7	76.1	....	....	85.7
XXIV.	Length-height index of head	$\frac{(23)}{(21)} \times 100$	54.6	55.6	52.5	53.7	....	....	74.9
XXV.	Sagittal-vault index	$\frac{(24)}{(27)} \times 100$	64.3	67.0	77.9	72.8	....	....	49.9
XXVI.	Face-trunk index	$\frac{(30)}{(2)} \times 100$	32.8	36.2	33.3	33.3	....	....	35.6
XXVII.	Relative size of upper face	$\frac{(31) \times 3}{(26)+(27)+(24)+(28)+(25)} \times 100$	11.8	12.4	16.5	15.0	....	....	9.8
XXVIII.	Vertical cephalo-facial index	$\frac{(30)}{(23)} \times 100$	80.0	80.2	126.9	116.6	....	....	58.0
XXIX.	Upper-face index	$\frac{(31)}{(32)} \times 100$	39.7	41.6	55.6	53.1	....	....	37.8
XXX.	Relative nasal height	$\frac{(33)}{(31)} \times 100$	75.6	78.2	92.0	92.3	....	....	66.4
XXXI.	Relative nasal breadth	$\frac{(34)}{(32)} \times 100$	30.3	30.8	27.3	24.5	....	....	28.0
XXXII.	Nasal index	$\frac{(34)}{(33)} \times 100$	101.1	94.8	53.5	50.0	....	....	111.7
XXXIII.	Relative interocular breadth	$\frac{(36)}{(32)} \times 100$	25.8	26.5	22.2	19.4	....	....	28.5
XXXIV.	Ear index	$\frac{(39)}{(38)} \times 100$	70.9	69.4	67.8	66.7	....	....	63.7
XXXV.	Relative size of ear	$\frac{(38) \times (39)}{(21) \times (29)} \times 100$	7.8	7.7	14.5	12.1			3.3

For the purpose of comparing the outer form of the Alouatta fetuses with that of the human fetus and of older Alouattas, and in order to describe the proportions of the former fetuses in an exact, numerical way, a series of measurements has been taken and indices of these have been formed. The technique of meas-

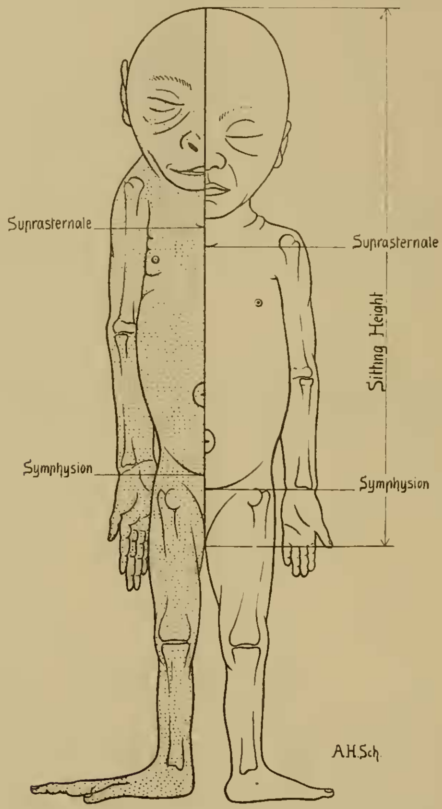

FIG. 19. SCHEMATIC DRAWING OF ALOUATTA FETUS (DOTTED HALF) AND NEGRO FETUS OF TWENTY WEEKS, REDUCED TO SAME SITTING-HEIGHT.

uring and the formulae for the indices, as well as the measurements and indices themselves, are compiled in tables 1 and 2. In drawing conclusions from these tables one has to be careful on account of the scarcity of the material and the considerable variability thereof. When more material is available, especially different genera and different stages of development, such conclusions will become safer and more extensive. In this paper I intend chiefly to place on record a detailed and accurate description of the two monkey fetuses and also to sketch in a preliminary way the changes during growth and some results of the comparison with human fetuses. The averages of the above tabulated measurements and of those of the human fetuses were used for the construction of a schematic drawing (Fig. 19) which may serve to illustrate the following remarks concerning the body proportions of the Alouatta fetuses.

The length of the trunk relative to the sitting-height is the same in the Alouatta fetus as in the human fetus; however, the different transverse diameters of the trunk, and the circumference of the chest are all relatively considerably smaller in Alouatta, which accounts for the slender appearance of the trunk in the latter. The adult condition is well expressed in the fetuses by the fact that, in relation to the length of the trunk, the width between the shoulders, as well as between the hips, is very much smaller in the Alouatta than in the human fetus. We know that, with the exception of the gorilla, man has the widest shoulders and hips of any of the adult primates. The shoulders of the Alouatta fetus are not only relatively closer together but they are also very much higher than in the human fetus, which fact constitutes a very marked difference between the two types. The thoracic index shows only a slight difference; in both types the transverse diameter of the chest surpasses the sagittal diameter. The somewhat larger average in human fetuses, however, points to a much more marked difference in later stages of growth, when the thorax is much broader in man than in any platyrrhine monkey, the latter having a deep and narrow chest. The nipples of the Alouatta fetus are considerably higher and more laterally situated than in the negro;[4] this close proximity of the mammae to the axillae is characteristic for most New World monkeys. The extreme in the very high and lateral position of the nipple in Alouatta is not reached until postnatal life, when the nipple may lie above the level of the suprasternal notch. The umbilicus of Alouatta lies relatively much higher than in the human fetus. From our findings on the trunk it is apparent that there exist

[4] The nipple of the Alouatta fetus lies over the third rib, in the human fetus between the fourth and fifth rib.

differences between the Alouatta and the human fetus in every point except in the relative length of the anterior wall of the trunk. The greatest differences consist in the shorter transverse diameters of the trunk, and the higher position of the shoulders, the nipples, and the umbilicus in the Alouatta.

The upper extremity is relatively considerably longer in the Alouatta than in the human fetuses; it reaches practically no farther down in Alouatta but is, as shown above, inserted higher than in human fetuses. In this difference in length the various parts composing the arm participate to a different degree. The relatively greatest difference exists in the length of the hand; somewhat less is the difference in the forearm, and least of all in the upper arm, but all three are relatively longer in the Alouatta. The relations of these parts to each other are expressed in the humero-radial and forearm-hand indices; according to the former, the radius, relative to the humerus, is longer in Alouatta, and according to the latter the hand, in relation to the forearm, is also very much longer in the monkey fetus. The humero-radial index in the adult Alouatta amounts to 91 according to Mollison ('10) and to 88 to 91.4 according to table 2. These figures are higher than the corresponding ones for the fetuses; therefore, the forearm in Alouatta has a greater rate of growth than the upper arm. According to the forearm-hand index, which in Alouatta decreases during growth, the hand has a slower rate of growth than the forearm. The human hand, in contrast to the hand of other primates, is characterized by its relatively greater breadth. This difference is already present in our fetuses, the hand index being larger in the human. During postnatal development the hand of Alouatta becomes still more slender. The length of the thumb in relation to the length of the hand is considerably less in the Alouatta than in the human fetuses, and this relation does not seem to change markedly during growth. The reduction of the thumb, typical for most monkeys, is, therefore, recognizable in fetal life. In the Alouatta fetuses fingers II to V are, in relation to the metacarpus, very much longer than the human fingers. Finger III is the longest but IV is almost as long, and finger II reaches about as far as finger V.

The lower extremity is relatively little shorter in the Alouatta, both femur and tibia being slightly shorter than in the negro fetuses. This minute difference is at first rather surprising, in consideration of the fact that man's lower extremity is relatively by far the longest of all primates. However, this distinction does not fully appear until some time during postnatal growth. The relation of the tibia to the femur is also only slightly different, the relative length of the tibia of the Alouatta being somewhat greater than of the negro fetus. During postnatal development the femoro-tibial index in Alouatta increases steadily. Martin ('14) states that this index increases during growth in all human races; it may, therefore, be concluded that the lower leg has a more intense rate of growth than the thigh, not only in man but also in Alouatta. The foot of the Alouatta is very much longer than that of the human fetus, and this, indeed, is one of the most marked differences between the body proportions in the two types. This difference is very pronounced in the relation of the foot length to the length of the tibia. The human foot is relatively the shortest of all the primates and this most probably holds true in fetal stages also. In both Alouatta and man the leg-foot index decreases markedly during growth. The fetal Alouatta foot is narrower and more slender than the foot of the human fetus. In the former the great toe is very much shortened, the second and third toes are of equal length, and the heel is not prominent.

In summarizing the results of this comparison of the extremities in Alouatta and human fetuses the greater length of the upper extremity in the Alouatta fetus and the approximately equal length of the lower one are points especially noteworthy. This different behavior in the relation of the upper to the lower extremity is precisely expressed in the intermembral index, which amounts to 136.7 in the Alouatta and to only 109.7 in negro fetuses. This index decreases during postnatal development in Alouatta as well as in man. The most distal portions of the extremities, the hand and the foot, in the Alouatta surpass in length the corresponding members of the human fetus to a greater extent than the more proximal parts. The thumb and the great toe especially is less developed in the Alouatta than in the human fetus.

It remains to consider briefly the proportions of the head. Here the most striking feature consists in the smaller size of the brain part of the head of the Alouatta as compared with the human fetus, a difference which is especially manifest in the height. There is a greater difference in the breadth than in the length of the head, as shown by the smaller cephalic index of the Alouatta, and a very much greater difference in height than in either of the other diameters, as shown in the length-height index, which is very much smaller in the Alouatta; the length, therefore, shows the least difference of any of the head diameters. The height of the face, from nasion to chin, is equal in the two types; the upper-face height is somewhat greater in the monkey, and the anterior part of the mandible is therefore less developed in height than it is in the human fetus. The breadth of the face shows but little difference, but the mouth is very much broader in Alouatta. The external nose is higher as well as broader in the monkey fetuses, the greater difference existing in height, so that the nasal index becomes considerably larger in the human fetuses. The low nasal index of our monkey fetuses is not restricted to platyrrhines, but is also found in fetuses of catarrhines and apes (Schultz, '20), in which also the nose is high relative to its width. In regard to the fetal nasal index, therefore, man seems to occupy an exceptional position among the primates. The relative interocular breadth is greater in adult man than in any adult monkeys or apes; it is therefore not surprising that the human fetus surpasses in this respect the Alouatta fetus, although not to such a degree as it would in the adult stage. The relative interocular breadth decreases in both Alouatta and man during growth. The nasal septum is very much broader in the Alouatta fetuses, which already show the typical features of the platyrrhine nose with laterally pointing nostrils. The ear of the Alouatta is considerably larger than that of the human fetus, a difference which becomes very evident when the size of the ear is expressed in percentage of the size of the head. The ear of the juvenile Alouatta is relatively almost twice as large as that of the fetus. In relation to its length, it is somewhat broader in the latter than in the average human fetus of that stage. The external meatus is situated farther back on the head in the monkey fetus. A further point of interest

FIG. 20. FRONT AND RIGHT SIDE VIEW OF HEAD OF ALOUATTA FETUS (TWIN A). APPROX. NATURAL SIZE

in the latter is the finding, on the lateral surface of the auricular fold, immediately behind the anthelix, of two low and not very distinct longitudinal folds, which without doubt, correspond to the (five) folds found by Schwalbe ('97) in human fetuses of four months. Figure 20 illustrates the typical features of the head of the Alouatta fetuses.

Following is a condensed description of points of interest on the integument of the Alouatta fetuses. In the latter, in contrast to human fetuses, there is no philtrum nor labial tubercle and the visible part of the mucous lips is extremely narrow. The lanugo of the Alouatta fetuses at this stage of development is restricted to the head. Very fine and short sparse hair is found on the forehead and over each zygoma in front of the ears. Longer, and somewhat more strongly developed hair occurs in the region of the chin and on the upper lip. These, with the exception of a few black ones on the upper lip, are very light. The eyebrows are formed by long, almost bristle-like sinus hairs, which are entirely black on the medial portions of the brows; the lateral parts consist of hairs black in their lower part and light at the end. A few of the outermost hairs in the brows are entirely light. There are no anlagen for sinus hairs on the cheeks of these twin fetuses, but such were found by Frédéric ('06) in three out of five Alouatta fetuses. No papillary ridges can be made out on the palms, soles, or ventral side of the tail; these apparently do not occur until later in fetal development.

The arrangement of pads (touch balls) and epidermal folds on the palm and sole is shown in figure 21. The finger nails, as well as the toe nails, are well developed and curved, in both longitudinal and transverse directions, especially in the latter, and resemble claws.

FIG. 21. RIGHT HAND AND FOOT OF ALOUATTA FETUS (TWIN A), TWICE NATURAL SIZE

A few remarks concerning the degree of resemblance between these twin fetuses of Alouatta may be of interest. One frequently finds the assumption that monozygotic twins are "identical", and this is especially expected in fetuses in which environmental conditions have not exerted an influence, as they do in postnatal life. Newman ('17) has collected sufficient proofs to show that absolute identity is never found, even in single-ovum twins. In comparing the columns for twin A with those for twin B in tables 1 and 2, it is at once apparent that there is no identity in the proportions of their bodies. All of the absolute measurements of A are larger than the corresponding ones of B with two exceptions—the upper-face height and the nasal height, which are slightly greater in twin B. The degree of resemblance between twins is most accurately obtained by figuring out the average percentage difference for all the absolute measurements taken. This is done according to the following formula:

$$\left\{ \sum \frac{m\ A - m\ B}{\frac{1}{2}\ (m\ A + m\ B)} \times 100 \right\} \div n$$

A stands for twin A, B for twin B, m for measurement, and n for the number of measurements used—in our case 39. The result thus obtained is 4.81, i. e., a measurement of twin B differs on an average from the corresponding measurement of twin A 4.81 percent. This rather high percentage is naturally affected by the difference in absolute size in general between the twins, but even if this were equalized, considerable difference would remain, as shown by the fact that the indices, likewise differ. The author's experience with human monozygotic twins, especially those of fetal stages, is analogous to that gained on these monkey twins, inasmuch as human twins also show upon closer examination a great number of more or less marked deviations. Finally, I may state that so far, I have never found human single-ovum twins, of any state of development, with exactly the same general size. This is also the case in the Alouatta twins, one being larger than the other.

For a study of the ossification and of the cartilaginous parts of the skeleton, X-ray photographs were taken of one of the Alouatta fetuses and the other one (twin A) was stained with toluidin blue and cleared in a three percent solution of potassium hydroxide and afterward placed in glycerine, a process which, in addition to the ossified parts, shows the cartilage in a dark blue color. For some points it became necessary also to partly dissect one of the fetuses in order to observe in detail certain conditions of the skeleton. Figure 22 is an exact drawing of the cleared specimen and may serve to illustrate the following description.

The spinal column consists of 57 vertebrae; 7 cervical, 14 thoracic, 5 lumbar, 3 sacral, and 28 caudal. These numbers occurred also in all the other Alouattas examined, with the exception of skeleton 3, which has only 27 caudal vertebrae. In table 3 the lengths of the different spinal regions are expressed in percentages of the praecaudal length of the spine. From the

FIG. 22. SIDE VIEW OF CLEARED ALOUATTA FETUS, SHOWING THE SKELETON. NATURAL SIZE

figures in this table it can be concluded that the cervical and the sacral regions of the Alouatta fetus are shorter than in human fetuses, whereas the thoracic region is considerably longer in the former than in the latter. It is furthermore of interest to note that in both Alouatta and man during growth the relative length of the thoracic region decreases, while the lumbar and sacral regions increase. In Alouatta the length of the caudal region is relatively greater in adults than in fetuses. This relatively greater rate of growth of the tail is also well expressed in the following percentage relations of the length of the latter to the sitting-height: Fetus A 109.0, fetus B 113.3, juvenile Alouatta (No. 1) 165.0, and juvenile Alouatta (No. 2) 165.7. Toldt ('03) found that the relative length of the tail changed very little during growth in case of *Macacus cynomolgus* L. This suggests the possibility that, whereas the tail of Alouatta is in a state of progressive evolution, that of Macacus is stationary, if not regressive, a suggestion which may be supported by the fact

TABLE 3. LENGTHS OF THE DIFFERENT SPINAL REGIONS IN PERCENTAGES OF THE PRAECAUDAL LENGTH OF THE SPINE IN ALOUATTA AND MAN.

	Region of spine: cervical	thoracic	lumbar	sacral	caudal
Alouatta seniculus macconnelli.... fetus (twin B)	17.0	49.3	22.7	11.0	133.5
Alouatta seniculus juv. (No. 1)...	13.4	47.5	26.0	13.1	186.7
Alouatta seniculus ad. (No. 3)....	14.8	45.1	27.3	12.8	160.0
Alouatta seniculus macconnelli.... adult (No. 4)	17.4	43.2	26.6	12.8	161.3
Human fetuses of 20 weeks.......	21.0	41.5	22.0	15.5	....
Human adults (Martin, '14)......	16.0	39.0	25.0	19.0	....

that in the genus *Macacus* there are several species with an almost rudimentary tail. In the spine of the Alouatta fetus each vertebra contains one ossification center for the body and, down to the fifth caudal vertebra one for each hemiarch. There are 14 ribs on each side, which are well ossified, their osseous shafts having about the same proportional length in regard to the costal cartilages as they have in the adult stage. The first eight pairs of ribs reach the sternum; the next two pairs are asternal ribs, and the remaining four pairs are floating ribs; even the last pair is still fairly long. This arrangement of ribs is the rule in the juvenile and the adult Alouatta also, with the exception of skeleton 3, in which only seven pairs of ribs reach the sternum and five pairs are floating ribs, the last pair being very short. The

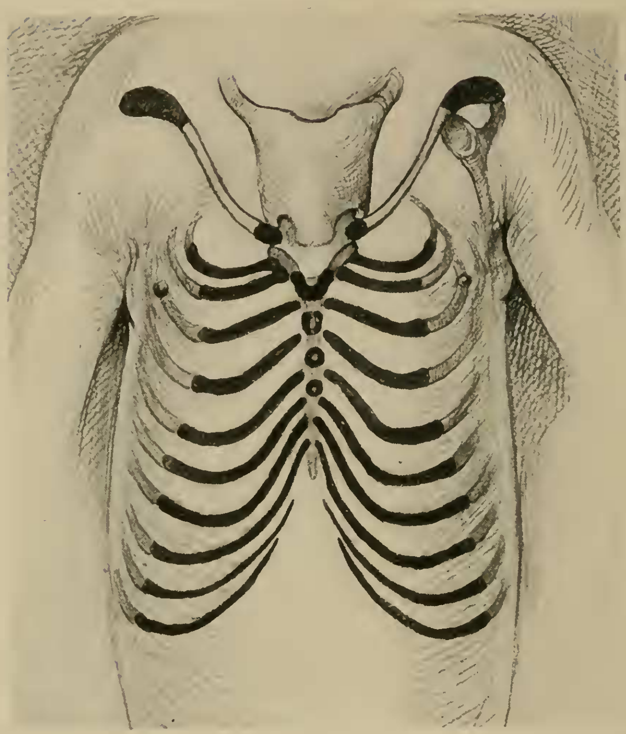

FIG. 23. SKETCH OF STERNUM OF ALOUATTA FETUS

sternum as yet shows no ossification centers. It is a slender cartilaginous structure in which only three ring-shaped zones and one uppermost, V-shaped zone are stained. The sternum of the adult Alouatta is distinguished by a unique condition—a splitting of the manubrium, due to the enormous development of the hyoid and larynx. It is extremely interesting to find this condition already present in the fetus. The cranial end of the fetal sternum forks into two diverging processes to which the two uppermost pairs of ribs and the clavicles are attached. Between these halves of the manubrium emerges the trachea from the thorax, and immediately above and almost in front of them lies the large hyoid (see figure 23). In the adult the second rib inserts somewhat lower on the sternum, not, as in the fetus, on the lateral process itself, but on the base of the latter, or even slightly below the forking of the two processes. The clavicles are well ossified and are curved S-shaped, very similar to that in the human fetus. The scapula has a greatest length equal to its greatest breadth, whereas in the adult state the breadth surpasses the length (from the glenoid cavity to the vertebral margin). The vertebral margin above the dorsal end of the spina scapulae is approximately one-half the length of the portion of this margin below the spine of the scapula. The latter portion of the vertebral margin has a concave contour, thus forming a scaphoid scapula. The acromial and coracoid processes are cartilaginous without ossification centers, as are also the dorsal edge and glenoid cavity of the scapula. The pelvis contains two pairs of ossification centers, one in the ilia and the other in the ischia; the pubic portion of the pelvis as yet shows no sign of ossification. The blades of the ilia are long and slender.

All the shafts of the long bones of the extremities are well ossified; there are no ossification centers in any of their epiphyseal ends. The humerus has no foramen entepicondyloideum, which is found in *Cebus* and other platyrrhines. On the humeri of the skeleton No. 3 there is a foramen supratrochleare on each side, but this is missing in the other specimens of *Alouatta* examined. The torsion of the fetal humerus, i. e., the angle between the axes of the caput and of the trochlea, amounts to 90 degrees, which is less than the torsion in human fetuses of corresponding development, in which I found this angle to vary from 98 to 130 degrees. The proximal end of the olecranon projects considerably beyond the incisura semilunaris, whereas the olecranon in the human fetus ends abruptly at the proximal end of the latter incisura. An analogous difference in the olecranon is found between modern adult man and adult monkeys, and it is interesting to see this distinction already clearly defined in fetal stages. The tibia in its upper portion shows a rather marked backward bend (proximal retroflexion). The carpus consists entirely of cartilage and contains a well-developed centrale, which at this stage of human development has disappeared from the wrist. Among the tarsial cartilages the calcaneus possesses a rather extensive ossified zone. In the human fetus this ossification center normally does not occur until the sixth month; this seems to be the only point in which the state of ossification of the Alouatta fetuses does not coincide with that of the human

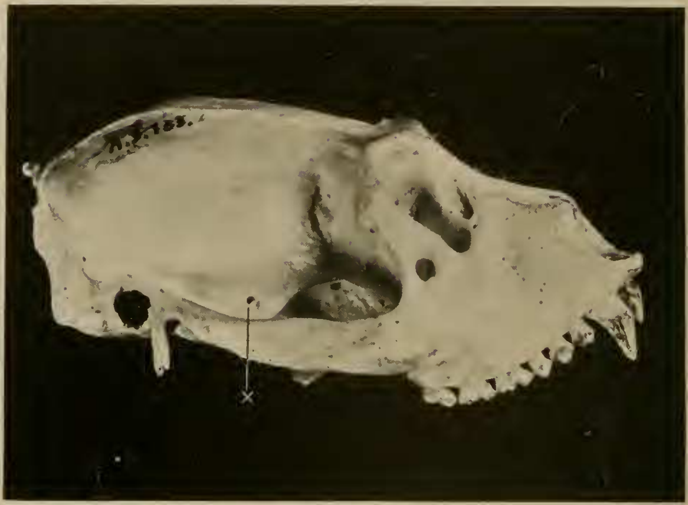

FIG. 24. SKULL OF AN OLD ALOUATTA SENICULUS WITH FORAMEN TEMPORALE AT X

fetuses of twenty weeks. At the distal end of each metacarpus and of the first metatarsus sesamoid cartilages are to be found.

Most of the elements of the skull of the Alouatta fetuses are already ossified to a considerable extent; apparently only the petrosum forms an exception in this respect. The great fontanelle sends a gradually narrowing arm almost as far as the naso-frontal suture and posteriorly communicates by a fairly broad arm with the occipital fontanelle; both are rather large. The two pairs of lateral fontanelles are small. From the frontal bone a process reaches toward the alisphenoid separating the parietal from the malar bone, a condition usually found in Alouatta, but contrary to the rule in other platyrrhines. The lacrimal fossa is situated almost outside of the orbit and is in full view when looking at the skull from in front. The foramen zygomatico-faciale is very wide. Where the orbital plate of the zygomaticum and the alisphenoid meet there is a foramen zygomatico-temporale of considerable size. This foramen has been described by Joseph ('76), who found it in all adult New World monkeys. It represents a vestige of the complete communication between temporal and orbital fossae found in Lemuroidea. The foramen is closed by a true membrana obturatoria orbitae. In our fetuses this foramen communicates by a narrow arm with the fissura orbitalis inferior, thus actually forming a continuation of the latter, which constitutes a more conspicuous remnant of the former full communication between the two fossæ. In the squama temporalis of the Alouatta fetus, over the root of the zygomatic arch, a fine foramen is to be found (x in figure 22). This foramen may correspond to that noted by v. d. Broek ('08) in the squama temporalis of *Ateleus*. I observed that the presence of this foramen is not restricted to the genus *Ateleus* but occurs also in many other platyrrhines.[5] Among the skulls of New World monkeys of my collection I found the foramen at a corresponding place and of relatively large size in eight *Alouatta seniculus* L. (see figure 24), including both juvenile and very old animals, in two species of *Ateleus*, and in one *Aotus boliviensis* Elliot. It was missing in all skulls of *Cebus* and of *Hapale* which I examined. This foramen is formed by an emissary vein; it may be called *foramen temporale*. In the skull of the very old *Alouatta seniculus macconnelli* (No. 4) no trace of it could be seen. This, and the fact that in the fetus of the same sub-species there is only an extremely fine foramen in the squama temporalis, which may be merely a foramen nutritium, makes it possible that this sub-species of *Alouatta seniculus* has no true foramen temporale. The ramus mandibulæ is broad and rather high; in later stages of growth this portion of the mandible of Alouatta increases enormously in size, enclosing the greatly enlarged hyoid. The hyoid capsule in the fetus is still cartilaginous, but already of a quite extraordinary size. The nasal cartilages are well developed and differentiated. The lateral nasal cartilage is of triangular shape and the greater alar cartilage encircles the nostril almost entirely, whereby its greatest surface is directed forward instead of sidewise, as in catarrhines.

The most interesting conclusion of this study is the fact that most of the typical differences existing between adult man and adult Alouatta—be it those of outer form or those of the skeleton—are already well defined in fetal stages, although not yet as pronounced as in the adult.

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[5] A rather large foramen on the corresponding place was found by the author in two human adult skulls of his collection (Nos. 266, white, and 216, negro).

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